COMPARATIVE EVALUATION OF PUSHOUT BOND STRENGTH AND APICAL SEALING ABILITY OF THREE DIFFERENT ROOT CANAL SEALERS: AN INVITRO STUDY

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BRANCH – IV

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ENDORSEMENT BY THE H.O.D. PRINCIPAL / THE HEAD OF THE INSTITUTION

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INTRODUCTION

Successful root canal treatment depends on the thorough debridement of the root canal system by elimination of pathogenic organisms and to seal the root canal space completely to prevent ingress of bacteria from the oral environment [(1)]. The physical properties necessary for this function include adaptation and adhesion of the filling material to the root canal wall, because gutta-percha does not directly bond to the dentine surface [(2)]. The sealer should be capable of producing a bond between core material and dentine wall.

The ultimate goal of root canal therapy is total obturation of the root canal system. Most of the obturation techniques utilize gutta-percha in conjunction with a cementing medium. However, sixty percent of failures in endodontic therapy may be due to inadequate sealing of the root canal system. [(3,4,5)] Other studies have revealed that inadequate flow of gutta percha and its inability to adhere to dentinal walls leads to an insufficient seal. Thus, over the years many different obturation techniques have been introduced in a hope of increasing the quality of the apical seal. [(6,7)]

Numerous studies have clearly demonstrated that when sealer is used with any obturation technique the apical seal is improved significantly [(8,9)]. Currently, none of the commercially available sealers possess all of the properties required to be considered an ideal root canal sealer. Therefore, dentistry must continue with research and development of new sealers until the perfect sealer is found. [(10)]

Lee *et al*. introduced mineral trioxide aggregate, a tricalcium silicate cement as a perforation repair material. Being bioactive it and biocompatible gained popularity for pulp capping, apexification, pulpotomy, and as root end filling material. Recently, it was developed as a root canal sealer and as an obturation material. When used as an endodontic sealer, MTA has been shown to have the ability to regenerate periodontal ligament and cementum in the periapical region. More recently, sealers based on

MTA have been introduced and found to have good sealing ability and higher push-out bond strengths. In addition, sealers based on MTA demonstrated hydroxyapatite-like deposits in contact with physiological solutions and a biocompatibility similar to MTA. A sealer of good working consistency could be developed by mixing MTA with adequate quantities of water-soluble polymer.[11]

Tricalcium silicate based MTA Plus root canal sealer which claims to have a “multitude of exceptional features, which makes it the most progressive and outstanding sealer on the market. Calcium silicate–based materials such as mineral trioxide aggregate based sealers have been claimed to be biocompatible, and to stimulate biomineralization, offering a superior seal. Also these materials found to exhibit better bond strength to dentin than zinc oxide eugenol based cements and have a sealing ability similar to epoxy resin based sealers [12].

AH Plus consisted of a paste-paste system, which was delivered in two tubes of epoxide paste and amine paste in a new double barrel syringe. Epoxide paste contained Diepoxide, Calcium tungstate, Zirconium oxide and Aerosil Pigment. Amine paste contains 1-adamantane amine, N,N'-dibenzyl-5-oxa-nonandiamine-1,9, TCD-Diamine, Calcium tungstate, Zirconium oxide and Aerosil Silicone oil . AH plus has gained popularity due to its radiopacity, biocompatibility, ease to use and availability. AH Plus knowned to be an epoxy-bis-phenol resin based sealer that also contained adamantine and bonds to root canal.[13]

The most commonly used sealers in root canal treatment are ZOE-based sealers. The powder of the sealer contains zinc oxide (ZnO), which combines with a liquid, generally eugenol and it has been used for its antibacterial properties which have been used in this study for comparison.

Over the past century, numerous obturation materials and techniques have been introduced in an attempt to obtain a microbiologic barrier within the confines of the root canal system. The lateral condensation of gutta-percha was the most widely used method of obturating the root canal system .[14] One major benefit of the single-cone technique was its simplicity, its predictability, relative ease of use, conservative preparation, and controlled placement of materials. Studies have showned that the single-cone technique with a suitable resin-based sealer could achieve the same rates of success than other types of obturation methods. The apical sealing ability of matched-taper single-cone obturation was comparable with that of lateral condensation.[15,16,17] The primary disadvantage of thermoplasticized guttapercha technique was that heated gutta-percha tends to contract as it cools.

Apical leakage was considered to be the common cause for endodontic failure and were influenced by many variables such as different filling techniques, chemical and physical properties of root canal filling materials and presence and absence of smear layer. Dye penetration, fluid filtration, dye extraction or dissolution method, bacteria and toxin infiltration method, air pressure method, electrochemical method etc were some of the various methods used for detection of microleakage. Micro push-out bond strength and dye penetration methods were used in the current study for detection of microleakage.[18,19]

The null hypothesis tested was that apical sealing ability and push out bond strength of three sealers are same and no differences in microleakage and pushout bond strength after single cone technique obturation.

AIMS

To evaluate and compare the Push out bond strength and Apical sealing ability of AH plus, Zinc Oxide Eugenol and MTA plus root canal sealers after obturation using single cone technique.

OBJECTIVES

1. To evaluate and compare the push out bond strength of gutta-percha after obturation in Coronal, Middle and Apical region of root canal using three different root canal sealers.
2. To evaluate and compare Apical microleakage after obturation using three different root canal sealers.

REVIEW OF LITERATURE

Limkangwalmongkol S (1992) compared the level of apical dye penetration of different sealers were used with lateral condensation of gutta-percha. Fifty single root canals were biomechanically prepared using the step-back technique and irrigation with 15% EDTA with cetrimide and 1% NaOCl solutions. The teeth were divided into five groups ,In the control group root canals were obturated by lateral condensation without any sealer and the other four groups were filled with laterally condensed gutta-percha and either Sealapex, Tubli-Seal, Apexit, or AH-26 sealer. The root surfaces were coated with nail varnish (except at the apex), and immersed in 2% methylene blue dye solution, and centrifuged at 30 x g for 3 min. The roots were sectioned longitudinally to determine the mean levels of dye penetration. This study demonstrated that root canal sealer should be used in conjunction with laterally condensed gutta-percha and that AH-26 sealer showed better results followed by apexit , Sealapex and Tubli-Seal. [20]

Yared GM (1996) evaluated the influence of various root canal sealers on the apical seal of vertically condensed gutta-percha. Human anterior teeth with single canals performed cleaning and shaping to an apical size 30 file and the teeth were divided into 4 equal groups of 30 teeth each. Then obturated with vertically condensed gutta-percha. In group 1, no sealer was used. In groups 2, 3, and 4, Kerr Pulp Canal Sealer, Roth 801 sealer, and AH 26 were used, respectively. Apical microleakage was determined using pressurized fluid filtration method and measured at different time intervals up to 24 week. Kerr Pulp Canal Sealer showed significantly better results than Roth 801 and AH 26 at 24 week. [21]

Dagher FB (1997) evaluated the microleakage of two Kerr root canal sealers (new and old formulas of the Pulp Canal Sealer). Sixty anterior teeth were used. After cleaning and shaping upto a size of 30 file, the teeth were obturated with vertical condensation of gutta-percha with either the old or the new root canal sealer. Apical microleakage was determined using pressurized fluid filtration technique at 90 min, 1 day, and 1, 4, 12, 18, and 24 week time interval after root canal obturation. The results showed that leakage tended to increase over time and no significant difference was found in microleakage between the new and the old formulas of the root canal sealer. (22)

L. C. Martens (1999) evaluated the apical seal of root canals filled with cold lateral condensation, hybrid gutta-percha condensation technique and with Soft-Core obturators. In maxillary anterior teeth cleaning and shaping done with a crown-down/step-back technique and obturated. All roots were immersed in India ink for 1 week. The degree of linear dye penetration was measured. The mean apical leakage for the Soft-Core technique was twice as extensive as for the two other gutta-percha obturation techniques. No statistically significant differences were found between the two other condensation techniques. (23)

Lyroudia K (2000) evaluated a new method for studying apical microleakage by using three-dimensional reconstruction method.biomechanical preparation done in human single-rooted mandibular teeth were used for this work. The teeth were divided into two groups that were obturated using two different sealers. India ink dye was used for passive stain. Serial cross-sections of 0.75 mm thick were taken from each specimen, using a microtome. Photographs were taken using stereoscopic microscope. Photographs were digitized and processed to obtain a 3-D reconstruction of external surface of the teeth, their corresponding prepared root canals, and their apical microleakage. Apical microleakage observed in both groups ranging between 2.25 to 8.25 mm height. The study has proved to be a novel useful tool in the study of apical microleakage. (24)

R. J. G. De Moor (2002) evaluated the long-term sealing ability (coronal and apical) of an epoxy resin root canal sealer (AH26) when used with different obturation techniques. Single-rooted teeth were taken and the canals were prepared according to the crown-down or step-back technique and using both 2.5% sodium hypochlorite and an EDTA paste. Obturation done using cold lateral condensation, hybrid condensation of gutta-percha and warm vertical condensation; and with Thermafil and Soft-Core obturators with same AH26 sealer in all cases. After root canal obtutation, each group was divided into five individual groups of 15 teeth and was kept for 1 day, 1 week, 4 months, 6 months and 12 months at 37°C in vacutainers in 80% relative humidity. The teeth were then immersed in India ink for 90 hours, each root was split and sectioned longitudinally, extend of leakage was measured using a stereomicroscope at ×6 magnification. The hybrid gutta-percha condensation technique showed better apical seal than other four obturation techniques in respect of apical leakage. Coronal leakage was significantly greater at all time periods for the Soft-Core system. [25]

Ari H (2003) evaluated the bond strengths of four adhesive systems to root canal dentin. Extracted human single rooted teeth were decoronated and root canals were then instrumented and irrigated with or without 5% NaOCl. The root canal dentin walls were bonded with Variolink II, C&B Metabond, Panavia F, or Rely-X. Microtensile bond strengths were measured using an Instron machine. The highest bond strength in C&B Metabond than Variolink II and Panavia F groups in the control group and NaOCl group.[26]

Gharai SR (2005) compared the forces generated during lateral compaction and the apical microleakage for nickel-titanium (NiTi) and stainless steel (SS) finger spreaders. Extracted human molar teeth were instrumented using standardized rotary instrumentation technique. NiTi and SS #30 spreaders were used for obturation and the forces generated during obturation were measured on a Universal testing machine. Apical microleakage was determined using fluid filtration method. There was no significant difference in microleakage between two type of spreaders. [27]

Vasiliadis L (2010) evaluated the *ex vivo* short term and long term microleakage along root canals filled with Gutta-flow and AH-Plus using the cold lateral compaction technique.

Single-rooted human teeth were sectioned below their cemento–enamel junctions to adjust a length of the roots to approximately 15 mm. The root canals were instrumented by step-back technique and filled using cold lateral condensation. The sealer used was either Gutta-flow (Group A) or AH-Plus (Group B). Microleakage evaluation was done by using a fluid transport model after periods of 1 week and 3 months. Study showed no significant difference between AH-plus and Gutta-flow in terms of sealing ability. [28]

Shokouhinejad (2012) compared push-out bond strength of a bioceramic endodontic **sealer**, EndoSequence BC **sealer** used with gutta-percha in the presence or absence of phosphate-buffered saline solution (PBS) within the **root canals**. Single-rooted human teeth were prepared and obturated with gutta-percha/EndoSequence BC **sealer**. The specimens were stored in PBS and underwent Push-out bond strength evaluation. The presence of PBS in the **root canals** increased the bond strength values of EndoSequence BC **sealer**/gutta-percha after 1 week. Whereas no difference was found between the bond strength of EndoSequence BC **sealer**/guttapercha in the presence or absence of PBS in the **root canals** after 2 month.[29]

Souza Bier (2012) studied about adhesiveness of six **root canal sealers**: Endo CPM, Epiphany, White MTA, Acroseal, Sealapex and **Sealer** 26 to dentin, in a push-out test design. Teeth were sectioned horizontally of 2 mm were prepared, rinsed with 5.25% NaOCl followed with 17% EDTA, and filled with one of the **sealers** and underwent bond strength evaluation after setting. The bond strength between endodontic **sealers** and **root** dentin was maximal bond strength was when Acroseal, **Sealer** 26 and Epiphany; where as Sealapex , Endo CPM, had the lowest bond strength.[(30)]

Bhardwaj (2013) Compared the sealing efficacy of the AH 26 with gutta percha, AH Plus with gutta percha and Resilon **sealer** with its obturator. The apical leakage study done by using the dye penetration methodology wiyh the help of a stereomicroscope. The highest microleakage in AH 26 , followed by AH Plus and Resilon **sealer with least microleakage** [(31)]

Carvalho (2013) evaluated the influence of calcium hydroxide paste used as intracanal medication to the bond strength of AH Plus and Epiphany sealers to root dentin. Maxillary first molars palatal canals were taken in human, using a rotary system. Half of the specimens were placed with calcium hydroxide for fourteen days and other half without. The calcium hydroxide were removed and filled with either AH or EP and underwent push out bond strength analysis. Regardless of the intracanal medicament used, AH plus showed higher bond strength values compared with Epiphany sealers.[(32)]

Evren (2013) compared the effect of photoactivated disinfection (PAD) on the bond strength between **root canal sealers and** human **root canal** dentin using a push-out test. Extracted and decoronated human mandibular premolar teeth were used and prepared with the ProTaper rotary system upto the size of the F3 file. The smear layer of the **roots** were removed by using 17% EDTA followed by 5.25% sodium hypochlorite and distillate water. The **roots** were grouped according to the final irrigation regimen. In group 1, PAD was applied to the **root canals** and a light curing for 20 seconds. In Group 2 finally irrigated with a 2% solution of chlorhexidine , whereas group 3 served as a control group (NaOCl

+ EDTA). After obturation with the lateral condensation technique using gutta-percha and AH Plus **sealer sealer**. One-millimeter-thickened horizontal sections from the coronal and middle thirds of each **root** were taken for the push-out bond strength measurement. Study showed that PAD do not adversely affect the bond strength between the AH Plus **sealer** and **root canal** dentin and that it can be used for final disinfection of **root canals**.(33)

Ozcan (2013) evaluated the sealing abilities of two different **root canal sealers** (epoxy resin-based AH Plus and polydimethylsiloxane-based GuttaFlow) and of five obturation techniques (lateral condensation, Thermafil, matched taper single gutta-percha point, laterally condensed-matched taper gutta-percha point and continuous wave of condensation), through a bacterial leakage model. Single-rooted human teeth were taken and were obturated with the test material, using the different **root** filling techniques and were mounted to a two-chamber bacterial leakage model and Enterococcus faecalis were added to the upper chambers. The lower chambers of all of the specimens were checked every day during the test period (100 days). The day of turbidity were noted for each sample. The continuous wave of condensation technique was found to be better than the other techniques. Both AH Plus and GuttaFlow **sealers** showed a similar levels of sealing ability. (34)

Shokouhinejad (2013) compared the bond strength of a bioceramic **sealer** (EndoSequence BC **Sealer**) and AH Plus based on the smear layer presence or absence. Extracted single-rooted human teeth were instrumented each underwent irrigation by 5.25% NaOCl and smear layer was not removed ; or the **root canals** were finally irrigated with 17% EDTA and 5.25% NaOCl to remove the smear layer. Then **root canals** were obturated using gutta-percha/AH Plus; or obturation was performed using gutta-percha/EndoSequence BC **Sealer** and underwent Push-out bond strength evaluation. In conclusion, the bond strength of the new..bond strength was simar for bioceramic **sealer** and AH Plus with or without the smear layer. (35)

Topçuoglu (2014) evaluated the effects of various gutta-percha solvents on the push-out bond strength between several **root canal sealers** and **root** dentine. Single-rooted human teeth were prepared using the ProTaper System (Dentsply Maillefer, Ballaigues, Switzerland) up to file size of F4. Different solvent type (Eucalyptol, chloroform and orange oil), at time (2 and 5 min), **sealer** type (MTA Fillapex, AH Plus and Sealapex) and at different **root** areas (coronal, middle and apical). After **obturation**, three 1-mm-thick slices were taken and underwent push-out bond strength test. The use of chloroform solvent for 5 min in the **root canal caused a** decrease of bond strength of all **sealers** but Eucalyptol and orange oil were no adversely affected the bond strength of the **sealers**. The push-out bond strength was highest for AH Plus group and lowest for MTA Fillapex group and decreses from coronal to apical. (36)

ULUSOY (2014) compared the effects of EDTA and maleic acid on the sealing ability of different **root canal sealers**. R**oot canals** were instrumented and irrigated with EDTA or MA. They were divided into groups and obturated as follows: Group 1: MA + Hybrid **Root** SEAL/gutta-percha. Group 2: EDTA + Hybrid **Root** SEAL/gutta-percha. Group 3: MA + iRoot SP/gutta-percha. Group 4: EDTA + iRoot SP/gutta-percha. Group 5: MA + EndoREZ/EndoREZ points. Group 6: EDTA + EndoREZ/EndoREZ points. Group 7: MA + AH Plus/gutta-percha. Group 8: EDTA + AH Plus/gutta-percha. The microleakage was measured after 2 min and 8 min using the fluid filtration method. The microleakage were minimum for the teeth obturated with EndoREZ selaers and AH Plus whereas maximum leakage were in Hybrid **Root** SEAL. Use of EDTA resulted in lower microleakage values compared with those using MA. (37)

Al-Dwairi (2015) compared the effect of resin-based endodontic **sealers** and eugenol-based on the push-out bond strengths of prefabricated fiber posts luting with different resin cements. Luting of prefabricated fiber posts were done into extracted single rooted teeth with either of three resin cements (ParaCore, Variolink II, or Rely X Unicem). Each group was again subdivided into three groups with 10 teeth each. Obturation done with gutta percha and each of endodontic **sealers** Endofil , TubliSeal and AH26 as three groups respectively. After push-out tests, highest mean bond strength value was recorded for the AH26 **sealer** group luted with Rely X Unicem resin cement , while the lowest mean bond strength value was observed with posts luted with Variolink II resin cement in the canal with endofil sealer and gutta-percha obturation done. [38]

Berkan Celikten (2015) used micro-CT to compare three different obturation techniques with respect to the voids occurrence in canal filled with bioceramic sealer. Extracted mandibular premolars were prepared with ProTaper Universal system. Obturation done using three techniques single-cone, lateral compaction, or Thermafil filling technique with gutta-percha and bioceramic root canal sealer. Assessment of voids in apical thirds was done with images taken from micro-CT. Highest Void volumes were for the single-cone technique and lowest for Thermafil, in all regions. [39]

Epita S (2015) evaluated tensile and shear bond strengths of one epoxy (AH plus) and two methacrylate resin-based sealers (EZ and RS) of varying thin and thick layers bonded to root dentine. Bond strength tests were conducted using an alignment device. Mode of failures in representative surfaces were evaluated. The study showed thick layer of sealer produced higher bond strength, except for EZ. Differences between thin and thick layers were found only in tensile bond strengths of RS and AH. Mixed type of failure was found with all sealers. Bond strengths of thin layers of resin-based sealers to root dentine tended to be lower than with thick layers. [40]

Elbatouty (2015) evaluated the push-out bond strength of the bioceramic **root canal sealer** (EndoSequence BC) in comparison to zinc oxide-eugenol-based (Kerr EWT) **sealer** and resin-based (AH Plus) **sealer**. Extracted r**oots** were divided into three groups with sealers EndoSequence BC; AH Plus; and Kerr EWT sealers. Two millimetre thickness horizontal sections at the coronal, middle, and apical thirds the **root** were sliced for the push-out bond strength measurement using universal testing machine after 7, 14 and 30 days. Scanning electron microscope used for mode of failure analysis. The study showed the highest mean push-out bond strength values after 1 and 4 weeks for EndoSequence BC, followed by AH Plus and Kerr EWT. After 2 weeks, the AH Plus had the highest mean push-out bond strength followed by EndoSequence BC. [41]

Ehsen Abdelmoumen (2015) compared the sealing ability of Zinc oxide eugenol sealer and resin-based sealer (Endo REZ) with two different root canal obturation techniques (cold lateral condensation and single cone technique). Human incisors, canines and premolars were selected and shaping done using protaper rotary files. Nail polish were applied to the tooth surface, after obturation except for the apical 2 mm. Evaluation of the sealing ability was performed by measuring the dye penetration along the canal walls for the different techniques. The apical sealing ability of EndoREZ is less effective as that of Zinc-oxide when used with other two different clinical obturation methods. [42]

Fernanda Leal (2015) evaluated the effect of different final irrigation techniques on push-out bond strength of epoxy resin root canal sealer to dentin. Single-rooted anterior teeth root canals were prepared using a rotary system, the final diameter was kept as #5 Gates-Glidden. During chemomechanical preparation, 2% CHX gel or 5.25% NaOCl was used. For smear layer removal, 17% EDTA or QMix 2 in 1 applied for 3 min. 1 mL of NaOCl, CHX solution or distilled water was used as final irrigant,. On conclusion of preparation, canals were filled with gutta-percha/AH Plus sealer. After obturation bond strength was measured by the push-out test. The group NaOCl/EDTA/NaOCl showed higher bond strength values than other groups. The final irrigant affect the push-out bond strength of AH Plus to dentin.[43]

Neelakantan (2015) evaluated the influence of various irrigation between **root canal sealers** and dentin and was analyzed by using Fourier transform infrared spectroscopy (FTIRS) . Single-rooted teeth were instrumented with 3% NaOCl as the irrigant divided into 4 groups based on irrigation protocol with 3% NaOCl, 17% EDTA as first group, ; 17% EDTA, 3% NaOCl, as second group ; 3% NaOCl, QMix, as group three and 3% NaOCl, water as group four. Again each group was divided into 3 subgroups on the basis of the **root canal sealer**: epoxy resin (AH Plus); silicone (RoekoSeal) and calcium hydroxide (Sealapex). The dislocation resistance was calculated by using push-out bond strength test. AH Plus showed the highest bond strength . Chemical bonding between AH Plus and dentinal collagen were revealed by FTIRS. The epoxy resin **sealer** (AH Plus) chemically bonds to dentinal collagen and irrigation protocol plays a major role in it.[(44)]

Pradeep (2015) used traditional gutta-percha, epoxy resin and DBA to make the **root canal** leak proof. Extracted maxillary incisors teeth were decoronated at cemento-enamel junction. Instrumentation done to size 40 and were randomly assigned to four groups according to the dentin adhesive system and obturation done with AH Plus **sealer** and gutta-percha points. The formation of hybrid layer was observed using scanning electron microscope and the dye penetration extension was measured using a stereomicroscope. Based on the hybrid layer divided into Control group without hybrid layer formation, Uniform thin hybrid layer, with short multiple resin tags and lateral branchings , Uniform hybrid layer with short and thick resin tag formations and Hybrid layer with numerous long discontinuous resin tags respectively as four groups. Group without adhesive showed the highest apical microleakage implying the need for dental adhesive.[(45)]

Levent Demiriz (2016) evaluated the adaptation ability of MTA Fillapex root canal sealer to dentinal wall using stereo electron microscope . Single-rooted, human maxillary incisor teeth root canals were prepared with a rotary nickel–titanium instrument to a size F3 file. Divided into two equal groups and one group was filled with AH Plus, and the other group was filled with MTA Fillapex using Gutta-percha single cone as a core material. The roots were performed for SEM evaluation, and scanning electron images were taken at ×50, ×100, ×500, and ×1000 magnifications. The gaps between the root canal sealer and canal walls were measured in coronal, middle, and apical thirds. The highest value among the detected gap formations was recorded for each section. MTA Fillapex has similar dentinal wall adaptation ability as AH Plus does.[(46)].

Patni PM (2016) investigated the effect of the apical seal obtained by different sealers used in with cold lateral condensation technique of obturation done gutta-percha using stereomicroscope. One hundred single-rooted extracted human permanent teeth with a single root canal were used in this in-vitro study. The sealers tested were conventional Zinc oxide eugenol, Roekoseal Automix (RSA) and Apexit, AH-Plus. The polydimethylsiloxane root canal sealer RSA provided a better apical seal followed by AH plus and Apexit, but conventional zinc oxide eugenol showed lowest sealing ability. The shrinkage related to setting and potential dissolution might be the reason for proper seal of the root canal leading to treatment failure. [47]

Ahuja L (2016) evaluated and compared the apical microleakage of a resin based sealer; Adseal with Mineral Trioxide Aggregate (MTA) based sealers; MTA Fillapex and Pro root MTA. Single rooted teeth were decoronated at cemento-enamel junction and biomechanical preparation done using endodontic rotary system. The teeth were randomly divided into five groups with n=15; Group I - Gutta-percha and Adseal ; Group II - Gutta-percha and MTA Fillapex; Group III- Gutta-percha and Proroot MTA; Group IV- Gutta-percha without sealer (positive control group) and Group V- Root canal remained empty (negative control). Root surfaces were covered with nail varnish except the apical 2mm and then immersed in 2% methylene blue dye for 72 hours. Roots were longitudinally splitted and linear apical dye penetration was measured under Stereomicroscope at 40X magnification. MTA Fillapex group showed maxmium apical microleakage followed by Pro root MTA and Adseal sealer.[48]

Widcha Asawaworarit (2016) evaluated the apical sealing ability of tricalcium silicate-based MTA Fillapex and resin-based AH Plus sealers at time periods 24 hrs, 7 days and 4 weeks. Decoronated human upper anterior teeth were instrumented using a set of ProTaper rotary instruments. Obturated with MTA Fillapex and gutta-percha and AH Plus and gutta-percha using a warm vertical compaction technique. The apical sealing ability was measured using the fluid-filtration method with 200 mm mercury (26.67 KPa) above atmospheric pressure at 24 h, 7 days and 4 weeks. MTA Fillapex had significantly more micro leakage than AH Plus 1 week after filling. After 4 weeks, AH Plus showed less result than MTA Fillapex . [49]

MATERIALS AND METHODS

Armamentarium used in the study:

- Extracted teeth
- Endodontic files size 8,10,15 size (Denstply Maillefer)
- X smart plus (Dentsply maillefer)
- Protaper Rotary files (Dentsply)
- Sodium hypochlorite (VIP Vensons, India)
- Normal saline (Nirlife NIRMA LIMITED)
- EDTA (Prevest Denpro)
- Guttapercha cones (Dentsply)
- Diamond disc and mandrel
- Chisel
- Scanning electron microscope (Zeiss sigma V)
- Olympus Zoom Stereomicroscope, Sz 40-45, Japan
- Methylene blue dye
- Kalpak universal testing machine
- Modelling wax
- Disposable syringe (Dispovan)
- Zinc oxide Eugenol sealer (Deepak Enterprise)
- AH plus sealer (Dentsply)
- MTA plus sealer (Prevest Denpro Limited)

SOURCE OF DATA

Extracted mandibular premolar teeth has been collected from department of Oral Maxillofacial surgery in KSR Institute of Dental science and Research, study has been conducted in the department of Conservative Dentistry and Endodontics in KSR Institute of dental science and research. Push out bond strength evaluation was done in LMPRD Laboratory, Erode

MATERIALS AND METHODS

This experimental study included 120 extracted single rooted teeth (Mandibular premolars) collected from department of Oral Maxillofacial surgery in KSR Institute of Dental science and Research. Extracted due to Orthodontic and Periodontic reasons

INCLUSION CRITERIA:

- Mandibular first premolars.
- Complete root formation without signs of internal or external resorption, no fracture or crack in the root.
- No coronal restoration or decay below the cemento enamel junction (CEJ)
- Straight cone-shaped root without curvature in the apical third.
- No calcification in the root canal.

EXCLUSION CRITERIA:

- K files #10 and #15 not passing beyond 11 mm from CEJ into the root canal.

PREPARATION OF THE TEETH

The collected teeth were cleaned immediately after extraction by removing all attached hard and soft tissues and immersing in 1000 ml of 5.25% sodium hypochlorite for 24 hours. Then the teeth were stored in the container with lid containing 0.9% sterile saline at room temperature until further processing. The crowns of the teeth were decapitated at the cemento-enamel junction with a diamond disk under water coolant. All prepared teeth were again held in 0.9% sterile saline at room temperature until the test time.

For root canal preparation, Xmart plus (DENTSPLY Maillefer) and Protaper (DENTSPLY Maillefer) with single length technique were used. The preparation of root canal were done upto F3 Protaper file. The system settings for all teeth were as follows: speed = 250 rpm, torque = 3Ncm. 2.5% NaOCl was used as an irrigant between each file. The final rinse was performed using 3 mL of 2.5% NaOCl and 17% EDTA, followed by 3 mL of normal saline. The root canals were dried with #30 paper points. To confirm drying of the canal, five consecutive #30 paper points were placed in the canal for five seconds and had to remain dry. The teeth were randomly divided into three groups, each containing 20 specimens. Obturation was done using single cone of 30 6% gutta-percha using Zinc oxide Eugenol, AH plus and MTA plus sealers.

GROUPING

Group I - Gutta-percha and Zinc oxide Eugenol sealer

Group II - Gutta-percha and AH Plus sealer

Group III- Gutta-percha and MTA Plus sealer

PUSH OUT BOND STRENGTH TEST

Out of obturated teeth, 60 teeth were taken for push out bond strength evaluation. 20 teeth from each group were horizontal sectioned at coronal, middle and apical thirds of root using a diamond disc with the help of a coolant. The sections were made uniformly of 2 mm thickness. At this time the apical side of the disk was marked to ensure the plunger of the push-out test pushed from the apical to coronal direction, to avoid any interference owing to root canal taper. Plunger tip end had a thickness of 0.5mm diameter.

A vertical load was applied to the obturation material in an apical to coronal direction at the rate of 0.5mm/min. A load versus time curve was plotted in real time by a software program connected to the universal testing machine. Failure of bond was determined when a sharp decline was observed on the graph. If any evidence of the plunger scrapping dentin was observed, the specimen was discarded and the data collected was not included in further analysis. The bond strength, expressed in MPa, was calculated by dividing the maximum load in Newtons by the area of the bonded interface. The area of the bonded interface was calculated using the formula, area = $2\pi r \times h$, where π is the constant 3.14 and r and h were the measured radius and height in millimeters of the filling material.

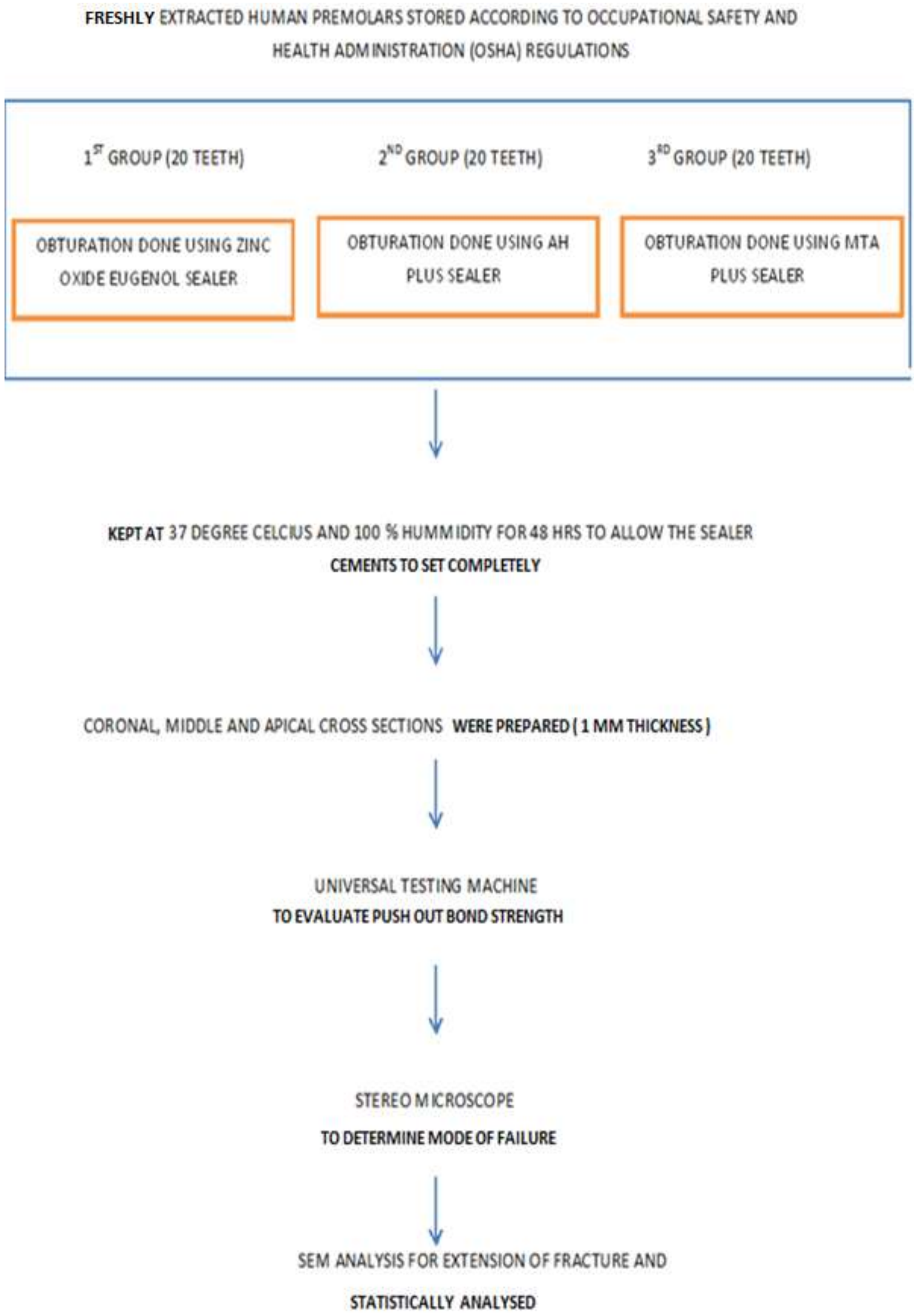
After the pushout bond strength test was performed, each of the root slices were examined under a stereo microscope at 40 X magnification to determine the failure mode.

Modes of bond failure were considered as follows:

(1) Adhesive Failure (Sealer / Dentine interface or Mastercone / Sealer interface)

(2) Cohesive Failure (Within the sealer)

(3) Mixed failure (Both adhesive and cohesive failure)


FRESHLY EXTRACTED HUMAN PREMOLARS STORED ACCORDING TO OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) REGULATIONS
1ST GROUP (20 TEETH)
2ND GROUP (20 TEETH)
3RD GROUP (20 TEETH)
OBTURATION DONE USING ZINC OXIDE EUGENOL SEALER
OBTURATION DONE USING AH PLUS SEALER
OBTURATION DONE USING MTA PLUS SEALER
KEPT AT 37 DEGREE CELCIUS AND 100 % HUMMIDITY FOR 48 HRS TO ALLOW THE SEALER CEMENTS TO SET COMPLETELY
CORONAL, MIDDLE AND APICAL CROSS SECTIONS WERE PREPARED (1 MM THICKNESS)
UNIVERSAL TESTING MACHINE
TO EVALUATE PUSH OUT BOND STRENGTH
STEREO MICROSCOPE
TO DETERMINE MODE OF FAILURE
SEM ANALYSIS FOR EXTENSION OF FRACTURE AND
STATISTICALLY ANALYSED

In all groups, the debonded surfaces of specimens were dried, mounted on aluminum stubs,sputter-coated with gold/palladium analyzed with a scanning electron microscope (Zeiss sigma V) to determine the extent of failure mode.

APICAL SEAL EVALUATION

The obturated teeth were isolated with modelling wax, leaving the apical foramen. The leakage was shown using dye penetration test with methylene blue. The external surfaces of all roots were made attached or bonded to a rod in such a way that apical 1 mm of each teeth touching the dye solution in a bowl. The roots were held vertically with the help of meshwork in a plastic box containing 2% methylene blue, so that only the apical 1 mm of each root were immersed in the dye. The roots were left in the dye for two days at 37 degree celsius, after which they were removed, washed and the wax covering was removed with scalpel. Teeth roots were sectioned longitudinally along the canal centers in buccolingual direction.

The binocular stereomicroscope (Olympus Zoom Stereomicroscope, Sz 40-45, Japan) were used to measure extent of dye- penetration up to the most coronal mark in micrometers (at magnification of X 40). The measurements of the dye penetration were done with the help of CMEIAS software. Micro scale tool in the CMEIAS software were used for measuring the extend of dye penetration. The data were collected and subjected to statistical analysis.

FRESHLY EXTRACTED HUMAN PREMOLARS STORED ACCORDING TO OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) REGULATIONS

1ST GROUP (20 TEETH)	2ND GROUP (20 TEETH)	3RD GROUP (20 TEETH)
OBTURATION DONE USING ZINC OXIDE EUGENOL SEALERS	OBTURATION DONE USING AH PLUS SEALERS	OBTURATION DONE USING MTA PLUS SEALERS

↓

DECORONATED AND OBTURATED SPECIMENS WERE USED

↓

ROOT SURFACES COATED WITH **MODELING WAX LEAVING APICAL FORAMEN**

↓

APICAL PORTION IMMERSED IN **2 %** METHYLENE BLUE AT 37 DEGREE **CELSIUS** FOR **2** DAYS

↓

WASHED WITH WATER AND LABIO LINGUAL SECTIONING DONE USING DIAMOND **DISC**

↓

STEREO MICROSCOPE

↓

STATISTICALLY ANALYSED

Figure 1 : Armamentarium used

Figure 2 : Armamentarium used

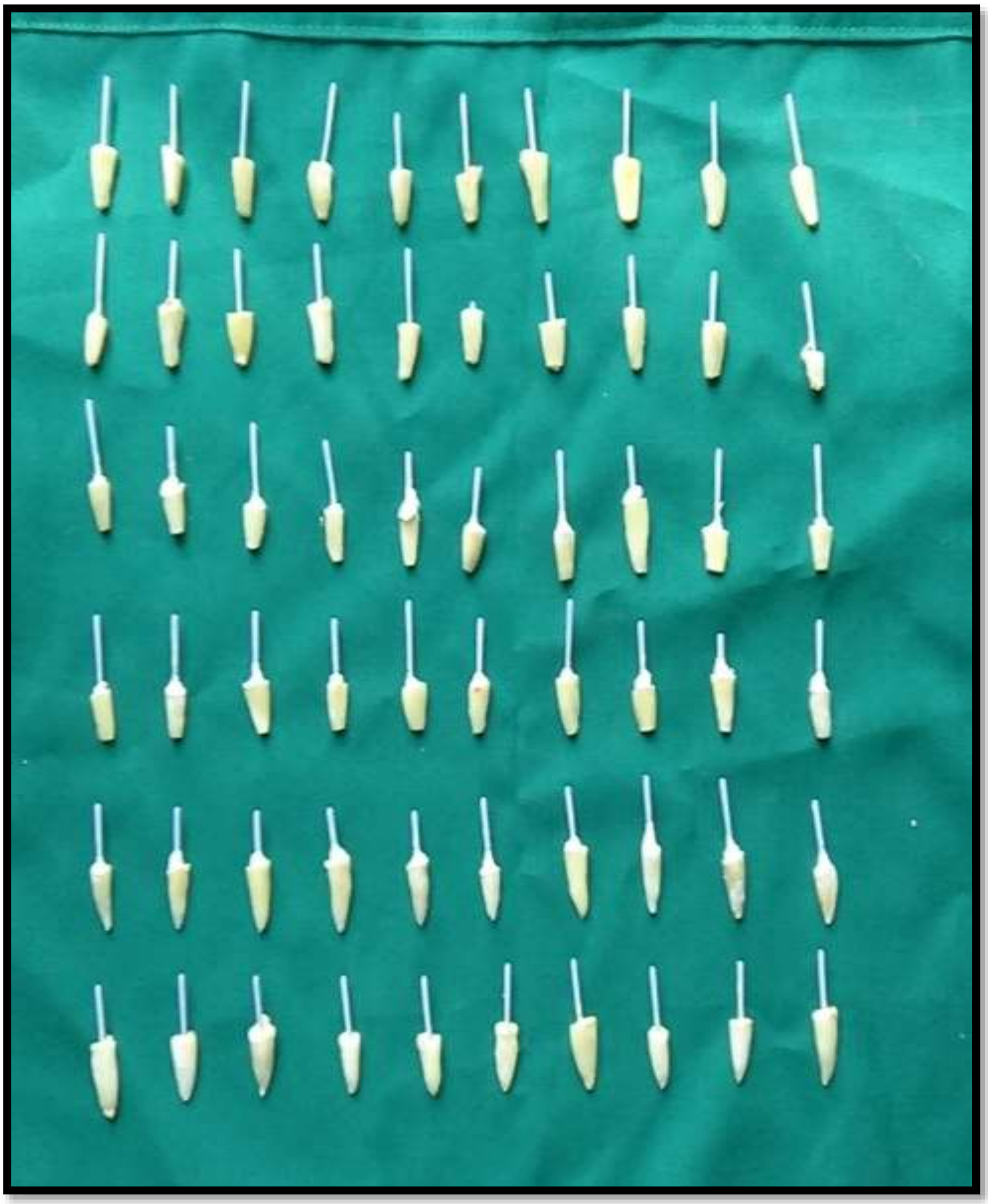


Figure 3: Teeth samples used

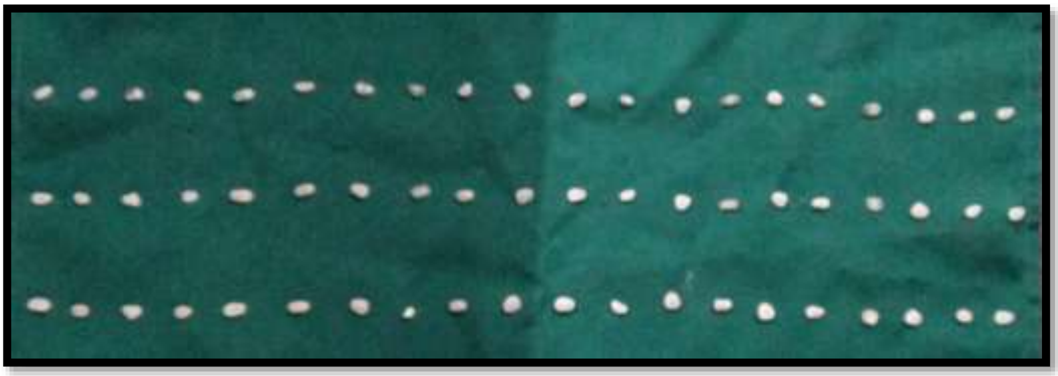


Figure 4 : Horizontal sections of teeth

Figure 5: Horizontal sections of teeth at Coronal, Middle and Apical region

Figure 6 : Push out bond strength examination using universal testing machine

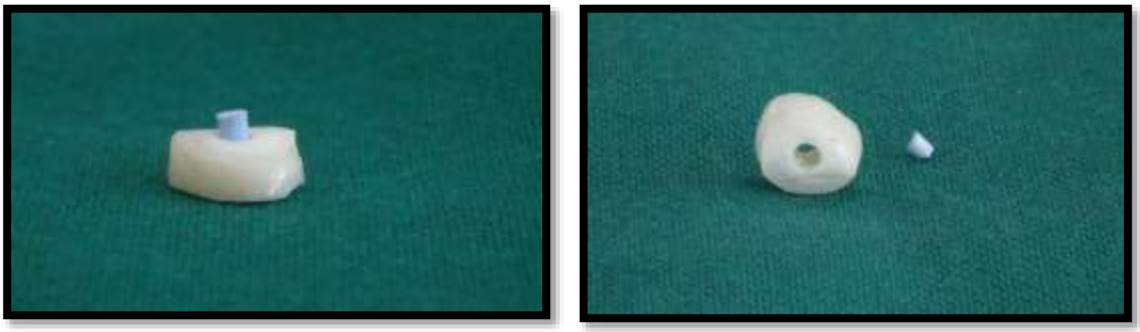


Figure 7: Extruded root canal filling materials after push out bond strength test

Figure 8: Specimens coated with wax except apical foramen before dye immersion

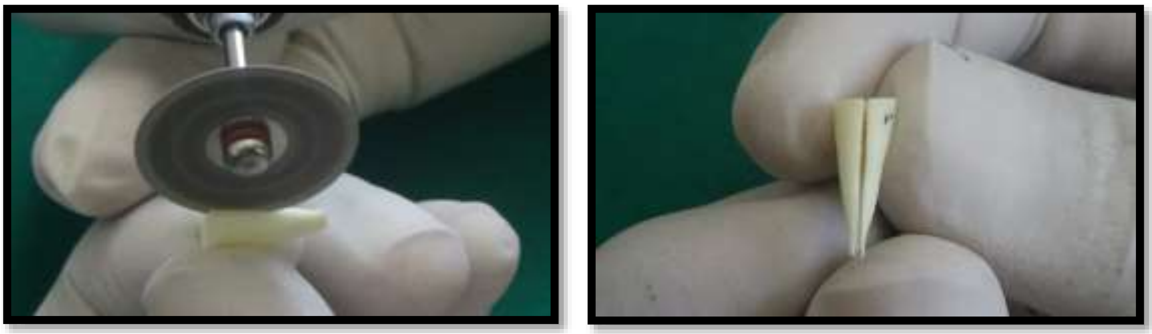


Figure 9: Longitudinal sectioning done after dye immersion

Figure 10 : Specimens before stereo microscopic evaluation

Figure 11: Stereo Microscope

Figure 12 : Scanning Electron Microscope Zeiss Sigma V used for Analysis

RESULTS

PUSH OUT BOND STRENGTH

Figure 13 : Adhesive failure

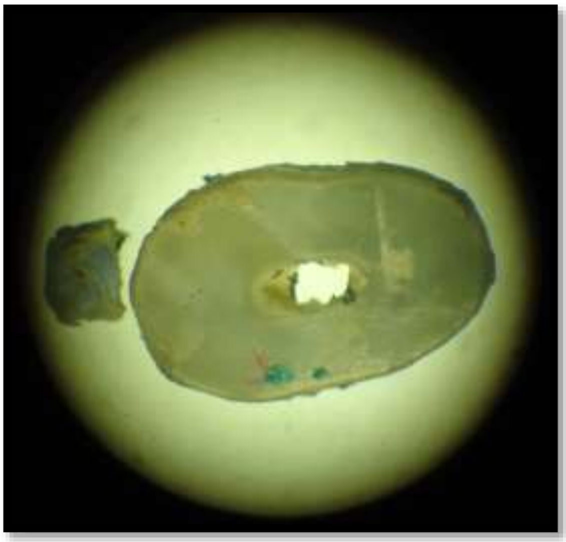


Figure 14 : Mixed failure

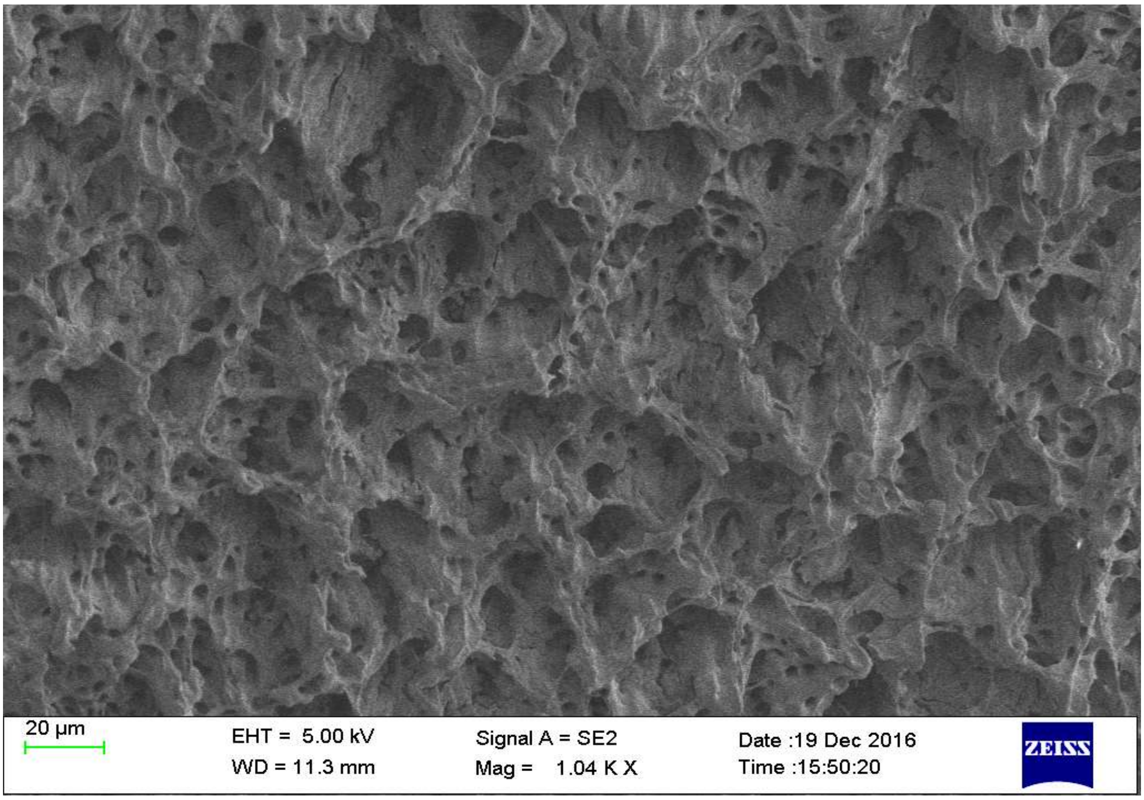


Figure 15 : Scanning electron microscopic image taken in root canal dentine surface after cleaning and shaping. The image shows thorough removal of smear layer prior to obturation

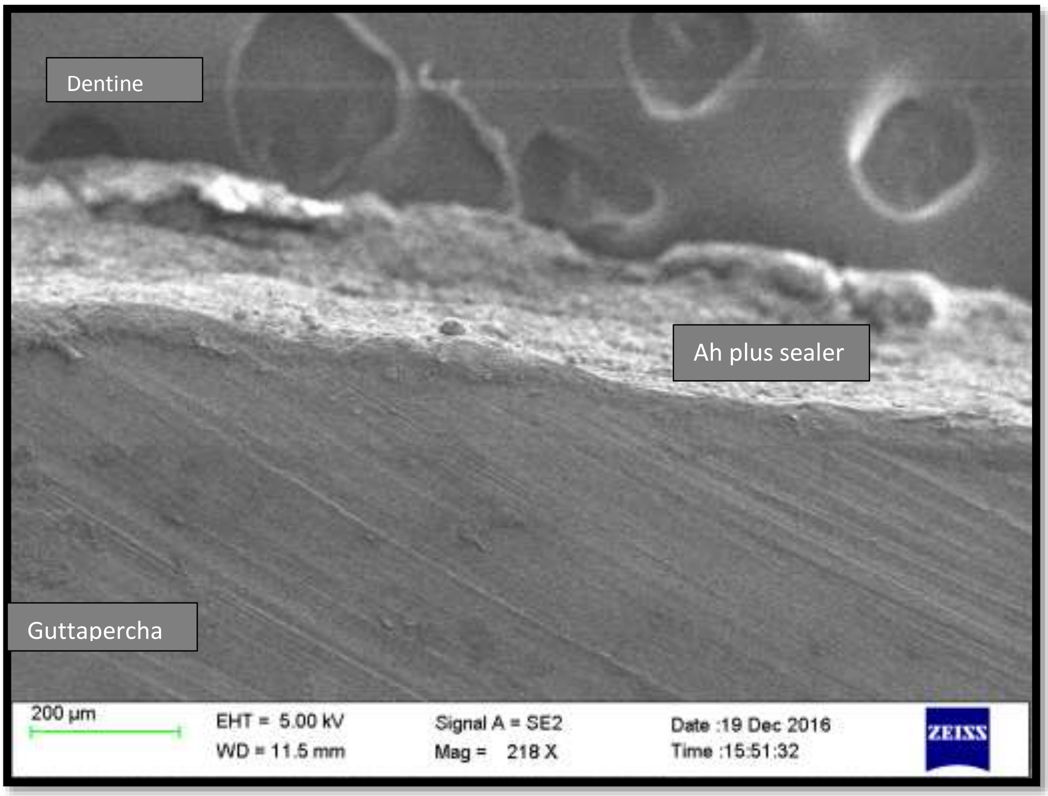


Figure 16 : SEM image of epoxy resin (AH plus) based sealer

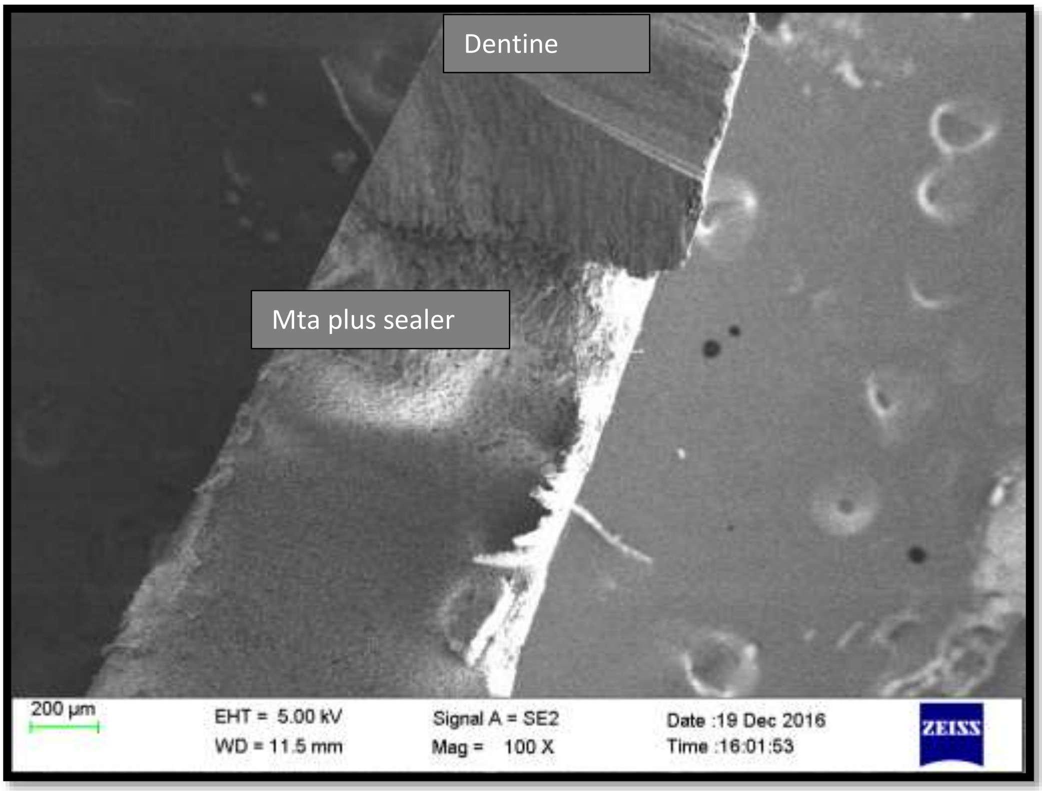


Figure 17 :SEM image of MTA sealer dentine interface

APICAL SEALING TEST

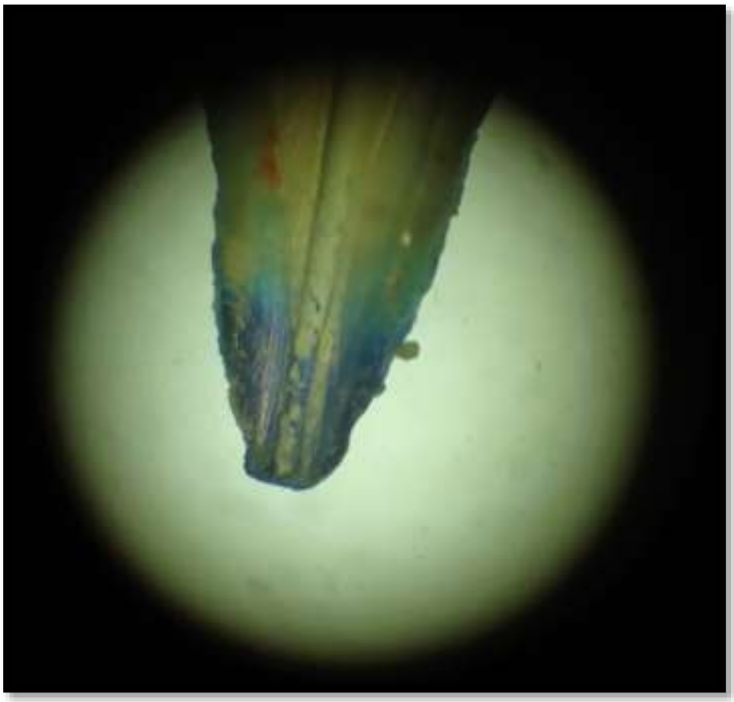


Figure 18 :MTA plus sealer group

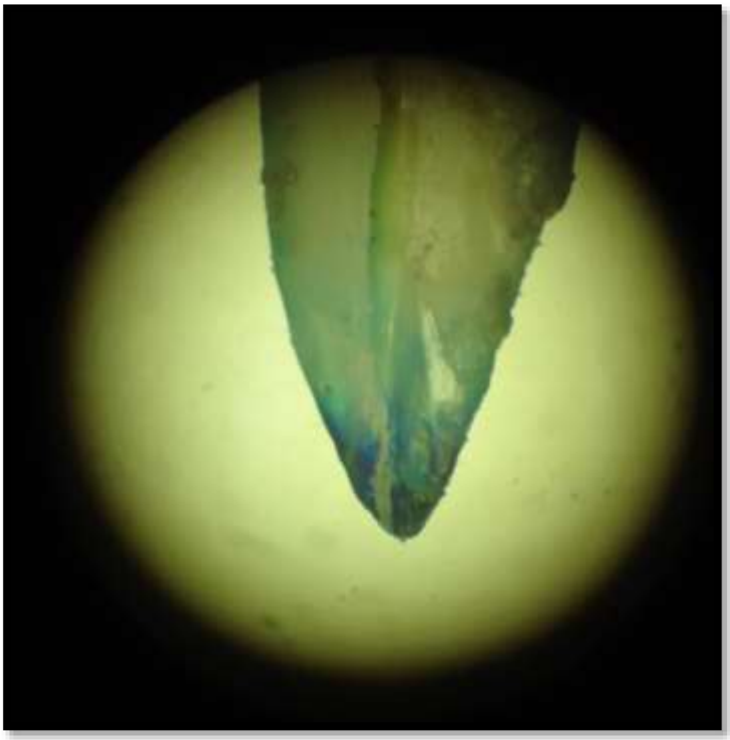


Figure 19 :Zinc Oxide Eugenol sealer group

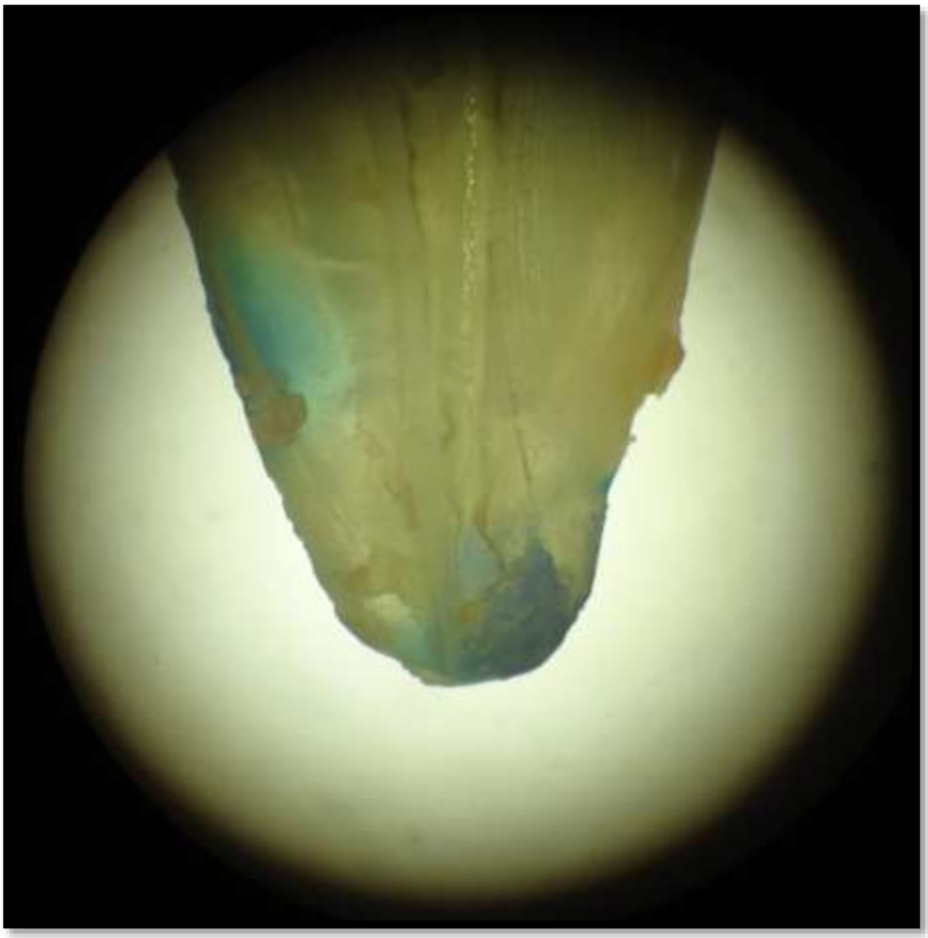


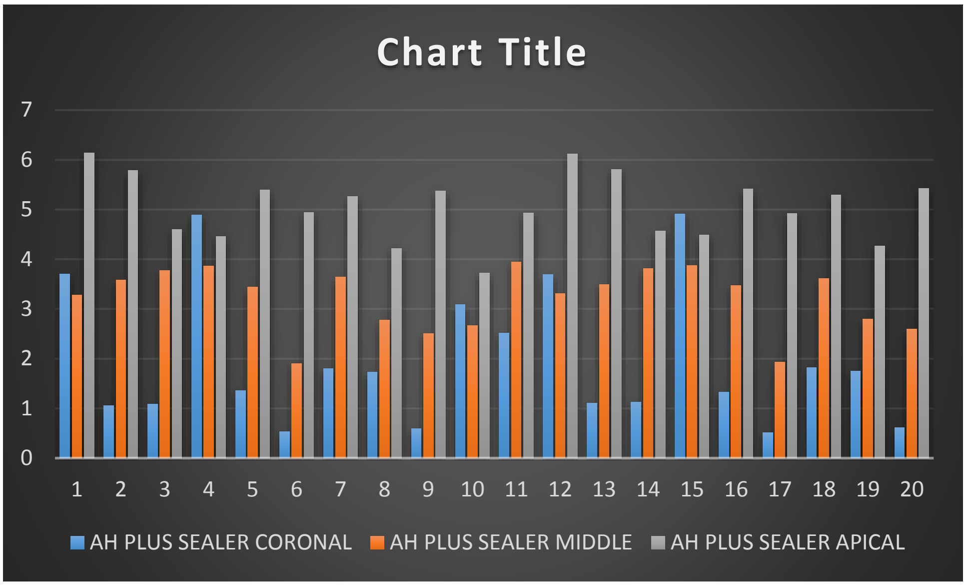
Figure 20 :AH plus sealer group

SL.NO	AH PLUS SEALER			ZINC OXIDE EUGENOL SEALER			MTA PLUS SEALERS		
	CORONAL	**MIDDLE**	**APICAL**	**CORONAL**	**MIDDLE**	**APICAL**	**CORONAL**	**MIDDLE**	**APICAL**
1	3.70	3.28	6.14	3.02	2.58	3.86	0.47	3.29	3.36
2	1.06	3.58	5.79	2.55	1.64	4.23	0.59	1.24	5.13
3	1.09	3.77	4.60	1.58	1.36	2.41	0.20	0.59	2.56
4	4.89	3.86	4.46	1.23	1.49	2.80	3.18	2.34	2.05
5	1.36	3.44	5.39	1.29	0.83	3.99	0.53	1.25	1.43
6	0.53	1.90	4.94	0.59	2.81	1.97	1.59	2.69	0.85
7	1.80	3.64	5.26	0.77	2.80	3.84	1.06	2.75	4.05
8	1.73	2.78	4.22	1.07	1.90	0.74	1.17	0.18	0.32
9	0.59	2.51	5.37	3.40	0.80	2.51	1.30	0.27	2.56
10	3.09	2.67	3.72	0.56	2.53	6.19	0.44	2.75	0.95
11	2.52	3.94	4.93	0.47	1.92	4.98	0.49	3.30	3.32
12	3.69	3.31	6.12	3.12	2.62	3.87	0.21	1.26	2.60
13	1.11	3.49	5.81	2.53	1.62	4.21	3.20	2.36	2.12
14	1.13	3.81	4.57	1.60	1.38	2.43	0.57	1.45	1.45
15	4.91	3.87	4.49	1.21	1.47	2.77	1.61	0.86	2.69
16	1.33	3.47	5.41	1.27	0.81	3.97	1.16	2.64	4.02
17	0.51	1.93	4.92	0.57	2.79	1.94	1.15	0.17	0.31
18	1.82	3.61	5.29	0.79	2.79	3.83	1.31	0.28	2.77
19	1.75	2.80	4.27	1.05	1.92	0.76	0.46	0.97	2.73
20	0.61	2.60	5.42	3.60	0.60	2.52	0.75	0.31	1.02

Table 1: Shows push out bond strength in N/mm^2 of various sealers

SL.NO	AH PLUS SEALER		
	CORONAL	MIDDLE	APICAL
1	3.70	3.28	6.14
2	1.06	3.58	5.79
3	1.09	3.77	4.60
4	4.89	3.86	4.46
5	1.36	3.44	5.39
6	0.53	1.90	4.94
7	1.80	3.64	5.26
8	1.73	2.78	4.22
9	0.59	2.51	5.37
10	3.09	2.67	3.72
11	2.52	3.94	4.93
12	3.69	3.31	6.12
13	1.11	3.49	5.81
14	1.13	3.81	4.57
15	4.91	3.87	4.49
16	1.33	3.47	5.41
17	0.51	1.93	4.92
18	1.82	3.61	5.29
19	1.75	2.80	4.27
20	0.61	2.60	5.42

Table 2: Shows push out bond strength in N/mm^2 of AH plus sealer

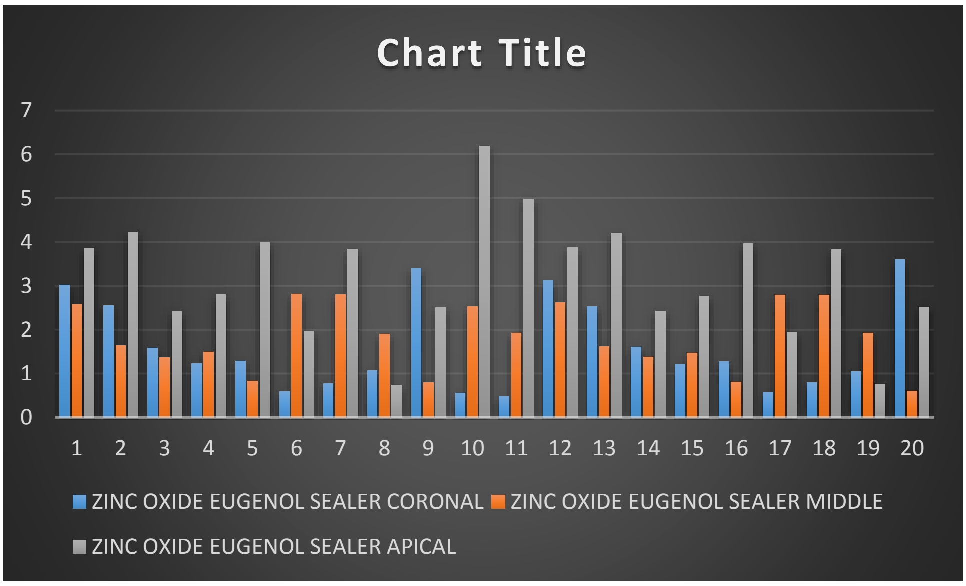


Graph 1: Shows push out bond strength in N/mm^2 of AH plus sealer

Sl.no	ZINC OXIDE EUGENOL SEALER		
	CORONAL	MIDDLE	APICAL
1	3.02	2.58	3.86
2	2.55	1.64	4.23
3	1.58	1.36	2.41
4	1.23	1.49	2.80
5	1.29	0.83	3.99
6	0.59	2.81	1.97
7	0.77	2.80	3.84
8	1.07	1.90	0.74
9	3.40	0.80	2.51
10	0.56	2.53	6.19
11	0.47	1.92	4.98
12	3.12	2.62	3.87
13	2.53	1.62	4.21
14	1.60	1.38	2.43

15	1.21	1.47	2.77
16	1.27	0.81	3.97
17	0.57	2.79	1.94
18	0.79	2.79	3.83
19	1.05	1.92	0.76
20	3.60	0.60	2.52

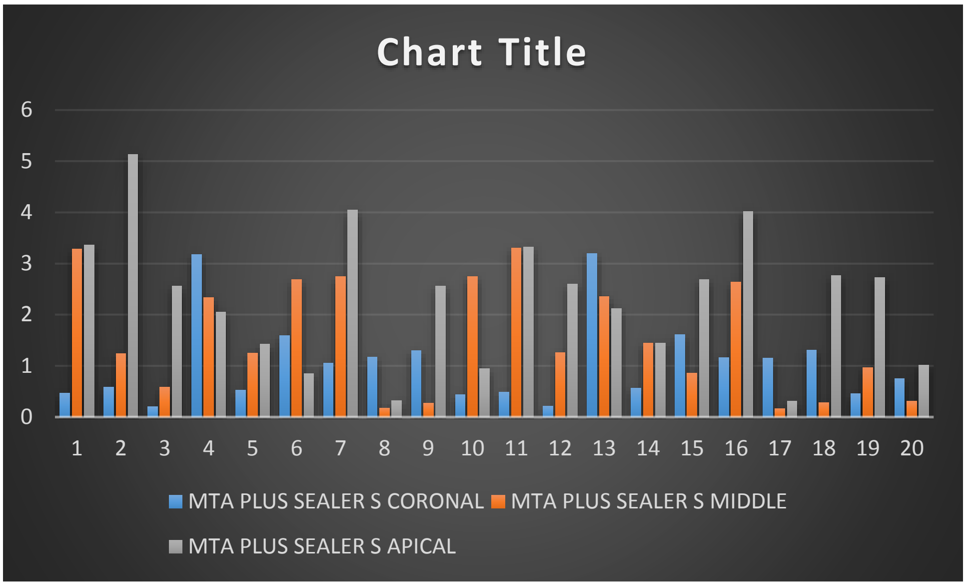
Table 3: Shows push out bond strength in N/mm^2 of Zinc oxide Eugenol sealer



Graph 2: Shows push out bond strength in N/mm^2 of Zinc Oxide Eugenol Sealer

Sl.no	MTA PLUS SEALERS		
	CORONAL	**MIDDLE**	**APICAL**
1	0.47	3.29	3.36
2	0.59	1.24	5.13
3	0.20	0.59	2.56
4	3.18	2.34	2.05
5	0.53	1.25	1.43
6	1.59	2.69	0.85
7	1.06	2.75	4.05
8	1.17	0.18	0.32
9	1.30	0.27	2.56
10	0.44	2.75	0.95
11	0.49	3.30	3.32
12	0.21	1.26	2.60
13	3.20	2.36	2.12
14	0.57	1.45	1.45
15	1.61	0.86	2.69
16	1.16	2.64	4.02
17	1.15	0.17	0.31
18	1.31	0.28	2.77
19	0.46	0.97	2.73
20	0.75	0.31	1.02

Table 4: Shows push out bond strength in N/mm^2 of MTA plus sealer

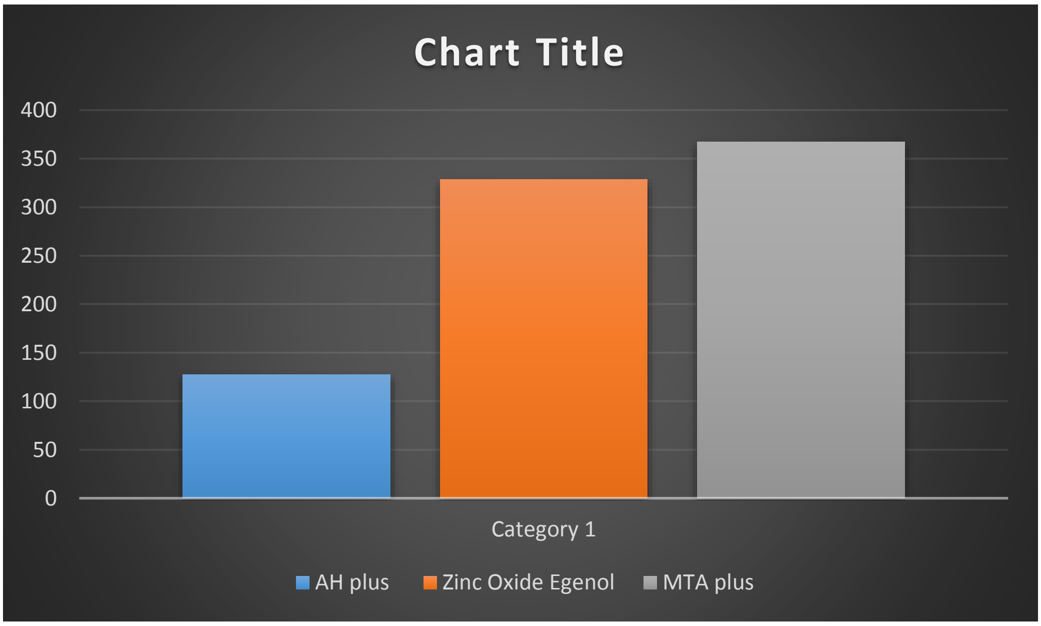


Graph 3: Shows push out bond strength in N/mm^2 of MTA plus sealer

Sl.no.	MICROLEAKAGE VALUES IN MICROMETER		
	AH Plus	Zinc Oxide Eugenol	MTA plus
1	76.92	348.75	563.78
2	189.02	405.01	615.82
3	162.36	263.9	339.48
4	114.07	474.4	479.45
5	56.57	712.64	263.35
6	64.76	254.39	205.08
7	149.35	531.87	211.37
8	98.27	483.35	366.59
9	114.54	261	248.29
10	75.18	173.12	168.96
11	174.93	362.49	202.81
12	138.46	342.12	349.05
13	113.14	267.59	576.68
14	116.48	305.76	279.58

15	152.05	393.24	184.2
16	149.58	475.6	182.48
17	122.08	262.21	246.6
18	135.69	324.9	554.35
19	160.37	317.32	212.76
20	184.34	385.4	324.9

Table 5: Apical microleakage of different sealers in micrometer



Graph 4: Apical microleakage of different sealers in micrometer

PUSH OUT BOND STRENGTH

Among the push out bond strength of the three sealers, the AH plus sealer group showed higher bond strength values. Lowest bond strength was in MTA plus group than in the zinc oxide eugenol group. Apical region showed more bond strength than than the coronal and middle region in all the sealer groups. Mean push out bond strength in AH plus group was 3.41 (SD ±1.59). The mean rank value for AH plus sealer in coronal region was 15.20 in middle region was 26.75 and in apical region was 36.67.

In zinc oxide eugenol group mean push out bond strength value were 2.21 (SD ±1.27). Coronal, middle and apical region showed a mean rank value of 21.78, 27.30 and 42.42 respectively.

MODE OF FAILURE

After the Pushout bond strength test was performed, each of the root slices were examined under a stereo microscope at 40 X magnification to determine the failure mode. Epoxy resin based sealer (AH Plus) with a main cone and sealer failed 10 % in adhesion between Dentine/Sealer interface and 90 % showed mixed type of failure, In zinc oxide eugenol group most of the failure mode was mixed type of failure where as MTA plus sealer group showed a few cohesive failure with remaining percentage of mixed type of failure.

APICAL LEAKAGE

The mean apical leakage was 2.74(SD ± 154.13). The highest microleakage was present in MTA plus group. The apical leakage was less in in AH plus group when compared to zinc oxide eugenol and MTA plus group.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
CORONAL_AH	20	1	5	1.96	1.388
MIDDLE_AH	20	2	4	3.21	.633
APICAL_AH	20	4	6	5.06	.659
CORONAL_ZOE	20	0	4	1.61	1.031
MIDDLE_ZOE	20	1	3	1.83	.754
APICAL_ZOE	20	1	6	3.19	1.351
CORONAL_MTA	20	0	3	1.07	.844
MIDDLE_MTA	20	0	3	1.55	1.108
APICAL_MTA	20	0	5	2.31	1.298
Valid N (listwise)	20				

Table 6: Mean bond strength of 3 sealers

	N	Mean	Std. Deviation
AH	60	3.410000E0	1.5915359
AH Group	60	2.00	.823

	AH Group	N	Mean Rank	Sum of Ranks
AH	Middle	20	10.75	215.00
	Apical	20	30.25	605.00
	Total	40		

Table 7: Mean bond strength of AH plus sealer sealers

	ZOE Group	N	Mean Rank
ZOE	Coronal	20	21.78
	Middle	20	27.30
	Apical	20	42.42
	Total	60	

	N	Mean	Std. Deviation
ZOE	60	2.212500E0	1.2682934
ZOE Group	60	2.00	.823

Table 8: Mean Bond Strength of Zinc Oxide Eugenol Sealer

	MTA group	N	Mean Rank	Sum of Ranks
MTA	Middle	20	17.08	341.50
	Apical	20	23.92	478.50
	Total	40		

	MTA
Mann-Whitney U	131.500
Wilcoxon W	341.500
Z	-1.853
Asymp. Sig. (2-tailed)	.064
Exact Sig. [2*(1-tailed Sig.)]	.063[a]

Table 9: Mean bond strength of MTA plus sealer

	Group	N	Mean Rank	Sum of Ranks
Coronal	AH	20	22.08	441.50
	ZOE	20	18.92	378.50
	Total	40		
Middle	AH	20	28.60	572.00
	ZOE	20	12.40	248.00
	Total	40		
Apical	AH	20	28.55	571.00
	ZOE	20	12.45	249.00
	Total	40		

P value < 0.05

	Coronal	Middle	Apical
Mann-Whitney U	168.500	38.000	39.000
Wilcoxon W	378.500	248.000	249.000
Z	-.852	-4.383	-4.355
Asymp. Sig. (2-tailed)	.394	.000	.000
Exact Sig. [2*(1-tailed Sig.)]	.398[a]	.000[a]	.000[a]

TABLE 10 :Mann whitney and Wilcoxon test comparing AH plus and Zinc oxide Eugenol group

	Group	N	Mean Rank	Sum of Ranks
Coronal	**AH**	20	25.18	503.50
	MTA	20	15.82	316.50
	Total	40		
Middle	**AH**	20	28.55	571.00
	MTA	20	12.45	249.00
	Total	40		
Apical	**AH**	20	29.90	598.00
	MTA	20	11.10	222.00
	Total	40		

P value < 0.05

	Coronal	Middle	Apical
Mann-Whitney U	106.500	39.000	12.000
Wilcoxon W	316.500	249.000	222.000
Z	-2.530	-4.355	-5.086
Asymp. Sig. (2-tailed)	.011	.000	.000
Exact Sig. [2*(1-tailed Sig.)]	.010[a]	.000[a]	.000[a]

TABLE 11 :Mann whitney and Wilcoxon test comparing AH plus and MTA plus group

	Group	N	Mean Rank	Sum of Ranks
Coronal	ZOE	20	23.98	479.50
	MTA	20	17.02	340.50
	Total	40		
Middle	ZOE	20	22.70	454.00
	MTA	20	18.30	366.00
	Total	40		
Apical	ZOE	20	23.62	472.50
	MTA	20	17.38	347.50
	Total	40		

P value < 0.05

	Coronal	**Middle**	**Apical**
Mann-Whitney U	130.500	156.000	137.500
Wilcoxon W	340.500	366.000	347.500
Z	-1.880	-1.190	-1.691
Asymp. Sig. (2-tailed)	.060	.234	.091
Exact Sig. [2*(1-tailed Sig.)]	.060[a]	.242[a]	.091[a]

Table 12 :Mann whitney and Wilcoxon test comparing zinc oxide Eugenol and MTA plus group

Kruskal Wallis test descriptive statistics in AH plus group showed high significance among Coronal , Middle and Apical region. Mann Whitney test showed there was a significant difference between Coronal region and Middle region, Coronal region and Apical region, and the Middle region and Apical region in AH plus group. In MTA plus group there was no statistically significant difference between Coronal region and Middle region, and Middle region and Apical region whereas Coronal and Apical region showed statistical significance difference.

In Zinc Oxide Eugenol there was no statistically significance difference between Coronal and Middle region. Whereas Coronal and Apical region , Middle and Apical region showed statistical significance.

MICROLEAKAGE

Descriptive Statistics

	N	Mean	Std. Deviation
Microleakage	60	2.744800E2	154.1306013
Group	60	2.00	.8 923

Table 13: Mean microleakage of three sealers

Kruskal-Wallis Test

Ranks

	Group	N	Mean Rank
Microleakage	**AH**	20	11.00
	ZOE	20	42.78
	MTA	20	37.72
	Total	60	

Table 14: Mean microleakage of each sealer

Descriptive statistical analysis of microleakage among the three groups were done using kruskal- wallis test. Inter group comparisons of microleakage was done using mann-whitney test. There was no significance difference in microleakage between MTA plus group and Zinc oxide Eugenol group. AH plus group and MTA plus group showed highly statistical significance. AH plus group and Zinc oxide Eugenol showed statistical significance.

DISCUSSION

The ideal requirement for root canal filling was that the entire root canal space should have no gaps or voids. Sealer and core materials should form a uniform, chemically bonded mass that should be bonded to dentine to minimize leakage.(1) In the current study three root canal sealers were compared by evaluating push out bond strength and apical sealing ability . With the development of resin-based sealers, the strength of the bond have received greater attention and the possibility of creating a 'monoblock' between the sealer and core material which bonds to the canal walls has introduced the prospect of strengthening the root-filled tooth against fracture .(50,51) The sealers included a tricalcium silicate-containing sealer(MTA Plus) , an epoxy resin-based sealer (AH Plus) and a zinc oxide eugenol sealer.

The result of study showed higher push out bond strength for Epoxy resin sealer.The sealer group interacted with dentine mechanically by penetrating into open dentinal tubules and moreover the penetrating ability was enhanced by smear layer removal . Pretreatment of the dentine surface with EDTA caused a significant increase in bond strength for epoxy resin based sealer and zinc oxide eugenol based sealer .(52) . AH plus had greater adhesion to root dentin , it could be likely due to the fact that, as an epoxy resin-based sealer, AH Plus had better penetration into the micro-irregularities because of its creep capacity and long setting time, which increases the mechanical interlocking between sealer and root dentin.(53)

Epoxy resin-based sealers have the possibility of adhesion to dentin with lower rates of water solubility, are well tolerated by tissues, have low water sorption, and have a potential of forming monoblock, thus reinforcing root canal.(54) This fact, allied to the cohesion among sealer molecules, increased the resistance to removal and/or displacement from dentin, which could be translated as greater adhesion.

The particle size of the filler had a decisive effect on the film thickness of the mixed material. AH Plus had a film thickness of 16 μm, which showed clearly below the value of less than 50 μm required by the ISO standard for root canal sealing materials whereas film thickness for MTA plus sealer showed as 47 μm. The quality of the root canal filling directly depends on the shrinkage upon setting and the solubility of the material used, as these properties were decisive for the impermeability of the treated root canal. AH plus (0.1 %) sealer showed much less solubility than MTA sealer (1.9 %) [55]

Push-out bond strengths of resin sealers were much lower when the sealer was present as a thin layer.[1] The MTA Plus kit includes 2 mixing liquids: a proprietary salt-free polymer gel and water. MTA Plus has been indicated as a root canal sealer as well as a root-end filling material and a pulp capping cement. By using the gel and varying the powder to gel ratio, different setting times and physical-rheologic properties can be obtained. The gel has been formulated to confer washout resistance, whereas its fine powder particle size improves handling and placement. Recent studies showed the possibility to perform retreatment of teeth filled with MTA cements [56,57] although it has been suggested to avoid filling procedures using MTA-like cements to completely obturate the root canal because the collagen and flexural strength of the dentin can be negatively affected[58]

No previous studies or articles were currently available for supporting the poor micro push out bond strength and apical sealing ability in MTA plus sealer. The poor sealing ability of MTA plus might be due to the presence of voids in the two interfaces of sealer. One study reported that the use of MTA as an orthograde filling material produced significantly higher percentage of voids than did GuttaPercha. Moreover, with MTA, several voids were observed in the apical region. MTA exhibited significantly poorer sealing quality in root canals with complex canal types; however, this difference was not observed in the root canals taken for this study.[59]

The reason for the low adhesion strength of MTA plus was reported to be the low adhesion property of its tag-like structures to root canal dentin.[60] MTA Plus in direct contact with fluids exhibited partial decalcification of calcium silicate hydrate in contact with the solution, microcracking and leaching of calcium hydroxide. Interaction with a physiological solution resulted in inhibition of hydration.[61]

The apical sealing ability of matched-taper single-cone obturation was comparable with that of lateral condensation and Thermafil techniques.[62] It has been shown that gutta-percha frequently separates from the sealer resulting in gap formation [63], which could be the "weak link" in endodontic therapy. Although some sealers might have adhesive properties to dentine (e.g. AH 26 and AH Plus, both epoxy resin based) (Dentsply Caulk, Milford, DE, USA) Bacteria could penetrate through the entire length of the canal as early as 19 days after obturation; the entire sample was contaminated in 90 days. It was obvious that the obturation material could be improved to prevent the passage of oral bacteria, or to entomb any remaining bacteria in the root canal, thus limiting their ability to cause disease in the periapical tissues.[64]

Wennberg et al found failure of adhesion to dentine in zinc oxide based sealers and failure of adhesion to gutta-percha for epoxy resin based sealer. The commonly used evaluation methods for apical microleakage methodology are fluid filtration method and dye extraction method. Other dyes like rhodamine, indian ink blue, malachite green, eosin etc were the other dyes that could replace the methylene blue which was used in the current study. Methylene blue dye was used in this study as its molecular size is similar to bacterial by-products such as butyric acid which can leak out of infected root canals to irritate periapical tissues, also it was easy to use, pH manipulation and availability add to it advantages.[65,66]

The setting reaction of zinc and eugenol was basically an ionic reaction, where eugenol acts as a proton donator (H^+). The setting mechanism of the zinc-oxide-eugenol-based cements was the result of equimolar mixtures of zinc oxide and eugenol, consisting of zinc oxide involved in a long crystal matrix of zinc eugenolate chelate. Any excess of eugenol get absorbed either by eugenolate and zinc oxide . Based on the research of Fragola, Brauer and Grossman et al, the influence of pH on the setting reaction could be explained as follows: zinc oxide (ZnO) reacts with water, producing zinc hydroxide ($Zn(OH)_2$). By reacting with hydrogen ($2H^+$), ionic zinc (Zn^{2+}) and water ($2H_2O$) are produced. Phenolic hydrogen from eugenol get substituted by zinc ions in order to form a zinc-oxide-eugenol chelate, the solidification of the cement then occurring. [67] Sealing properties of ZnOE sealers were inferior in comparison to other sealers due to the relatively high solubility of the ZOE sealer; so, adhesion between guttapercha and zinc oxide eugenol was weak. [68]

The results of this study were similar with the results of many other studies comparing the bond strength of epoxy resin based sealer and tricalcium silicate based sealer to dentin. [69,70,71,72] Generally these studies have been showned gutta-percha and AH Plus to have higher bond strengths than MTA based sealers and zinc oxide based sealers obturation systems.

The presence of phosphates in the canal has been reported to enhance biomineralization and also increased the push-out bond strength of calcium silicate-based materials. When EDTA was used as final irrigant chelating agent opens dentinal tubules and exposes dentine collagen fibrils enhancing the sealers entrapping in dentine structure . Also the residual EDTA chelates calcium from the materials and the dentine, resulted in more free calcium helped to provide bonding[73,74].

Push-out test has been described to measure the bond between sealer, canal wall and the core material. The test was intended to assess the extent to which the sealer and core material were bonded into a solid mass as well as the strength of the bond to the canal wall.[75]

The push-out bond strength test was one method to evaluate the effectiveness of root canal obturation material or technique. The other methods of testing include bacterial leakage, fluid filtration and dye penetration testing [76]. While every method of *in vitro* testing supposed to replicate the clinical environment, and the correlation between leakage studies and clinical success has been questioned.[77] The push-out models has been used widely to evaluate dentin obturation interface, but its relevance has also been called into question.[78] There was also no evidence that any of these methods was the best for measuring clinical effectiveness of root canal obturation material or techniques.

The current study demonstrated that highest mean bond strengths were found at the apical segment of each group. This could be due to the pooling of sealer at the apical segment as an evident during obturation. Each tooth was prepared so that tug-back was felt when placing the master cone. This demonstrates a tight fit that could cause an influence in push-out bond strength. The apical segments exhibited highest standard deviation. This might be due to the small diameter of obturation material found near the apex. Attempts were made to match the diameter of the plunger which used in the push out testing compared to the diameter of the filling material to prevent the plunger touching the wall of the canal. All the slices were examined under 40X magnification after push-out. If evidence was found that the canal wall touched the sample was discarded. The middle and coronal segments were more easily aligned using the push-out plungers by minimizing the need to discard slices than the apical segments.

SUMMARY

The present study was done in the Department of Conservative and Endodontics ,KSR Institute of Dental Science and Research. After taking approval from institutional review board,a randomised control trial was planned. . The ultimate goal of root canal therapy is total obturation of the root canal system. The physical properties necessary for this function included adaptation and adhesion of the filling material to the root canal wall, because gutta-percha does not directly bond to the dentine surface. Ideally, the sealer should be capable of producing a bond between core material and dentine wall. So the present study aimed to evaluate and compare the push out bond strength and apical sealing ability of AH plus, Zinc Oxide Eugenol and MTA plus root canal sealers after obturation using single cone technique. Total of 120 mandibular premolar teeth were used and decoronated. All teeth were prepared using protaper rotary file system upto F3 file size using Xmart plus (DENTSPLY Maillefer) and obturated with guttapercha size of final instrumentation using single cone obturation technique. The irrigation solution used after each instrumentation were 2.5% NaOCl, 17% EDTA and normal saline. Samples were grouped into three based on the root canal sealer used of each group containing 40 number of teeth. In Group I, specimens, obturation done using Gutta-percha and zinc oxide Eugenol sealer; Group II - Gutta-percha and AH Plus sealer and Group III- Gutta-percha and MTA Plus sealer. Half of the specimens in each group were used for push out bond strength analysis. Horizontal sections of 2 mm thickness were made from coronal, middle and apical region of samples and underwent push out bond strength test with the help of universal testing machine at a cross head speed of 0.5 mm/ min. Specimens were analysed using stereo microscope for the mode of failure and extent of fracture using scanning electron microscope. Remaining half of the specimens were coated with modelling wax except apical foramen and immersed in methylene blue for 2 days. Stereo microscopic photographs of each samples were taken and linear measurement was calculated using CMEIAS software.

The findings of the present study can be summerized as follows:

1. AH plus sealer group showed the highest push out bond strength than Zinc oxide Eugenol and MTA plus root canal sealer.

2. Apical segment of each test group demonstrated the highest mean bond strengths than the coronal and middle segments.
3. Apical microleakage value in AH plus sealer group was less on comparing Zinc Oxide Eugenol and MTA plus root canal sealer.

CONCLUSION

Within the limitations of the present study, push out bond strength values of each sealer were different and varied significantly in each area of root canal Coronal, Middle and Apical. AH plus sealer showed higher push out bond strength than Zinc oxide Eugenol and MTA plus root canal sealer. Apical segment of each test group demonstrated the highest mean bond strengths than the coronal and middle segments Apical microleakage value in AH plus was less on comparing zinc oxide Eugenol and MTA plus root canal sealer.

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APPENDIX – I

ABBREVATIONS

- SEM – Scanning Electron Microscope
- EDTA – Ethylene diamine tetra acetic acid.
- MTA – *Mineral trioxide aggregate*
- ZOE – Zinc oxide Eugenol
- STD – Standard deviation
- GRP – Group
- Asymp. Sig – Asymptomatic significance
- Exact Sig – Exact significance
- CEJ – Cemento Enamel Junction

INSTITUTIONAL ETHICAL COMMITTEE

KSR INSTITUTE OF DENTAL SCIENCE & RESEARCH

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Ref.: 079 /KSRIDSR/EC/2014 **Date : 26.11.2014**

To

Dr.C.P.Sreedev,
Postgraduate Student,
Dept. of Oral Medicine & Radiology,
KSR Institute of Dental Science & Research,

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Your dissertational study titled "COMPARATIVE EVALUATION OF PUSH OUT BOND STRENGTH AND APICAL SEALING ABILITY OF THREE DIFFERENT ROOT CANAL SEALERS – AN INVITRO STUDY" presented before the ethical committee on 24th Nov.2014 has been discussed by the committee members and has been approved.

You are requested to adhere to the ICMR guidelines on Biomedical Research and follow good clinical practice. You are requested to inform the progress of work from time to time and submit a final report on the completion of study.

Signature of Member Secretary
(Dr.G.S.Kumar)